SCIENCE

A WEEKLY RECORD OF SCIENTIFIC PROGRESS.

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SCIENCE:

A Weekly Record of Scientific Progress.

JOHN MICHELS, Editor.

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SATURDAY, MAY 28, 1881.

In his recent address to the Royal Microscopical Society of London, the President, Dr. Lionel S. Beale, F. R. S., introduced some interesting facts relating to the present limits of microscopic vision, and indicated the advance that may be anticipated for the future in this direction.

Within five years it has been often asserted by those who make the Physics of the Microscope their special study, that the limits of microscopic vision had been almost reached by modern objectives, and that further advance was barred by insuperable difficulties. Since this time the record of progress contains numerous instances of advances made beyond these barriers which authorities considered until now insurmountable. Dr. Beale claims that "he only who is quite ignorant of the many and great improvements made in our methods of research, and in the instruments required for investigation, would think of fixing any limit to the advance of microscopical inquiry."

With improved instruments, the Microscopists have discovered improved methods of preparing objects for examination, and subtle agents united with the most delicate manipulation are now employed to develop structure, requiring the highest power of microscopic definition and amplification. We remember with Dr. Beale the time (within ten years) when in many branches of inquiry it was truly said that the optical instruments were in advance of the methods of making examinations, when our magnifying powers were higher than we could use, without losing, rather than gaining, as regards the definition of delicate structure. All this has now changed; the power of definition of objectives has been more than doubled, but the Biologist, in his investigations, anxiously demands higher powers and more perfectly corrected objectives.

Until recently the Histologist was satisfied with powers of five to six hundred diameters. Dr. Beale, in his recent address, states: "Our present limit of observation in investigations on the structure and action of the tissues of man and the higher animals, in my opinion, includes the use of magnifying powers of 2000 diameters. Objects considerably less than the hundred-thousandth of an inch can be studied with advantage, but how much less than these dimensions cannot, I think, be determined with accuracy at this time; for so much depends upon the character of the object, and a number of small points of detail as regards mode of examination.

But in other departments of Microscopical research our present means of investigation enable those familiar with the requisite methods of inquiry to demonstrate characteristics of structure far more intricate and minute than the above remark would infer. Various modifications of immersion lenses and in immersion media have greatly contributed to advance our knowledge of structure and action in the lower forms of life, and there is every reason to think that, as time goes on, methods of observation will be still improved and new methods discovered."

Another aid to perfect Microscopy is Photography, for by its use "things dimly seen by the eye may be very distinctly and correctly delineated, and with a perfection of accurate detail which a few years ago we should not have supposed possible." In this direction Dr. Beale states that "in all probability the application of photography to investigations upon minute structural details will be carried far beyond anything yet reached, although it is really wonderful how much has been achieved up to this time."

It will thus be seen that a variety of circumstances is steadily leading the way to what may be termed A NEW MICROSCOPY.

Both the Microscope and objectives, as also methods of manipulation, are being *revolutionized*, producing entirely new results. Even a new style of literature of the subject is developing. As far back as June, 1875, the editor of this journal, in a paper prepared for *Popular Science Monthly*, then foreshadowed this change. The article was headed, "*The Microscope and its Misinterpretations.*" A happy satisfaction then reigned among Microscopists, both with their instruments and their work, and the article was criticised as an assault upon the integrity of Microscopical research. It is some satisfaction to the present writer to find that those who then came forward as champions of the perfect microscopical work of that day, are now the most active leaders of the *new reform.* We refer to Mr. John Phin, the present editor of *The American Journal of Microscopy*, who can claim the honor of having established the first successful microscopical journal in the United States, and Professor J. Edwards Smith, of Cleveland, the author of

the recent book "How to see with the Microscope," a work which is a valuable addition to Microscopical Literature; both wrote articles against "*The Misinterpretation of the Microscope.*" In that article we gave very strong illustrations of the "*misrepresentations*" referred to, but the paper was written some years in advance of the present developments, which have made the case much stronger. The disputed resolution of the "Podura" scale was then quoted as an instance of an objective giving two distinct resolutions of an object, one of which was clearly an erroneous one, but who would have then anticipated that the spherules on "*Angulatum*" which we have for so many years religiously regarded as the true ultimate resolution of that diatom, would prove to be an illusion? While to make the case more complicated, Professor E. Abbe states that "while it is not my opinion that the *Angulatum* valve is composed of spherules, yet even if such should exist, they would not have a different effect."

Thus "*The Misinterpretation of the Microscope*" under certain conditions, is no myth, but an admitted fact; we welcome then the improvements which shall at least partially remedy the evil. The high angle objectives of the present, although far from perfect, give great hope for the future, and we trace in Professor Smith's work, to which reference has been made, the advent of a higher intelligence among Microscopical workers. This new spirit of progress is well described by Dr. Beale when he says, the Microscopist, like the Astronomer, is ever longing to get a little beyond the point at which he has already arrived. Each new fact gained by research seems but to indicate the existence of more and more important things beyond. Limit is reached and then surmounted, but soon a new limit seems to rise from the mists in the distance towards which the worker is impelled by new hopes and desires. It is this never-halting progress which distinguishes scientific from every other kind of inquiry, and particularly microscopical investigation, for it can never be completed. It deals with the illimitable. The boundaries of to-day are found to have vanished to-morrow, and the eyes and understanding begin to penetrate into regions which but a short time before had been considered far beyond the range of possible investigation.

CONDUCTIBILITY OF GLASS FOR THE GALVANIC CURRENT. —According to A. Sewarz, if two platinum wires are interposed in the same circuit, the one passing through the free air while the other lies between two glass plates, or is melted into a thick capillary tube, at a certain temperature of the tube the former glows brilliantly, while the second remains dark. If the glass becomes heated the former grows dark, whence the author concludes that the glass has become more conductive.

THE PRODUCTION OF SOUND BY RADIANT ENERGY.*

By ALEXANDER GRAHAM BELL.

In a paper read before the American Association for the Advancement of Science, last August, I described certain experiments made by Mr. Sumner Tainter and myself which had resulted in the construction of a "*Photophone*," or apparatus for the production of sound by light; † and it will be my object to-day to describe the progress we have made in the investigation of photophonic phenomena since the date of this communication.

In my Boston paper the discovery was announced that thin disks of very many different substances *emitted sounds* when exposed to the action of a rapidly-interrupted beam of sunlight. The great variety of material used in these experiments led me to believe that sonorousness under such circumstances would be found to be a general property of all matter.

At that time we had failed to obtain audible effects from masses of the various substances which became sonorous in the condition of thin diaphragms, but this failure was explained upon the supposition that the molecular disturbance produced by the light was chiefly a surface action, and that under the circumstances of the experiments the vibration had to be transmitted through the mass of the substance in order to affect the ear. It was therefore supposed that, if we could lead to the ear air that was directly in contact with the illuminated surface, louder sounds might be obtained, and solid masses be found to be as sonorous as thin diaphragms. The first experiments made to verify this hypothesis pointed towards success. A beam of sunlight was focussed into one end of an open tube, the ear being placed at the other end. Upon interrupting the beam, a clear, musical tone was heard, the pitch of which depended upon the frequency of the interruption of the light and loudness upon the material composing the tube.

At this stage our experiments were interrupted, as circumstances called me to Europe.

While in Paris a new form of the experiment occurred to my mind, which would not only enable us to investigate the sounds produced by masses, but would also permit us to test the more general proposition that *sonorousness, under the influence of intermittent light, is a property common to all matter*.

The substance to be tested was to be placed in the interior of a transparent vessel, made of some material which (like glass) is transparent to light, but practically opaque to sound.

Under such circumstances the light could get in, but the sound produced by the vibration of the substance could not get out. The audible effects could be studied by placing the ear in communication with the interior of the vessel by means of a hearing tube.

Some preliminary experiments were made in Paris to test this idea, and the results were so promising that they were communicated to the French Academy on the 11th of October, 1880, in the note read for me by Mr. Antoine Breguet.‡ Shortly afterwards I wrote to Mr. Tainter, suggesting that he should carry on the investigation in America, as circumstances prevented me from doing so myself in Europe. As these experiments seem to have formed the common starting point for a series of independent researches of the most important character, carried on simultaneously, in America by Mr. Tainter,

*A Paper read before the National Academy of Arts and Sciences, April 21, 1881.

† Proceedings of American Association for the Advancement of Science, Aug. 27, 1880; see, also, American Journal of Science, vol. xx, p. 305; Journal of the American Electrical Society, vol. iii, p. 3; Journal of the Society of Telegraph Engineers and Electricians, vol. ix, p. 404; Annales de Chimie et de Physique, vol. xxi.

‡ *Comptes Rendus*, vol. xcl, p. 595.

and in Europe by M. Mercadier,† Prof. Tyndall,‡ W. E. Röntgen,§ and W. H. Preece,‖ I may be permitted to quote from my letter to Mr. Tainter the passage describing the experiments referred to:

METROPOLITAN HOTEL, RUE CAMBON, PARIS,
Nov. 2, 1880.

DEAR MR. TAINTER:

* * * I have devised a method of producing sounds by the action of an intermittent beam of light from substances that cannot be obtained in the shape of thin diaphragms or in the tubular form; indeed, the method is specially adapted to testing the generality of the phenomenon we have discovered, as it can be adapted to solids, liquids, and gases.

Place the substance to be experimented with in a glass test-tube, connect a rubber tube with the mouth of the test-tube, placing the other end of the pipe to the ear. Then focus the intermittent beam upon the substance in the tube. I have tried a large number of substances in this way with great success, although it is extremely difficult to get a glimpse of the sun here, and when it does shine the intensity of the light is not to be compared with that to be obtained in Washington. I got splendid effects from crystals of bichromate of potash, crystals of sulphate of copper, and from tobacco smoke. A whole cigar placed in the test-tube produced a very loud sound. I could not hear anything from plain water, but when the water was discolored with ink a feeble sound was heard. I would suggest that you might repeat these experiments and extend the results," &c., &c.

Upon my return to Washington in the early part of January,†† Mr. Tainter communicated to me the experiments he had made in my laboratory during my absence in Europe.

He had commenced by examining the sonorous properties of a vast number of substances enclosed in test-tubes in a simple empirical search for loud effects. He was thus led gradually to the discovery that cotton-wool, worsted, silk, and fibrous materials generally, produced much louder sounds than hard rigid bodies like crystals, or diaphragms such as we had hitherto used.

In order to study the effects under better circumstances he enclosed his materials in a conical cavity in a piece of brass closed by a flat plate of glass. A brass tube leading into the cavity served for connection with the hearing-tube. When this conical cavity was stuffed with worsted or other fibrous materials the sounds produced were much louder than when a test-tube was employed. This form of receiver is shown in Fig. 1.

Mr. Tainter next collected silks and worsteds of different colors, and speedily found that the darkest shades produced the best effects. Black worsted especially gave an extremely loud sound.

As white cotton-wool had proved itself equal, if not superior, to any other white fibrous material before tried, he was anxious to obtain colored specimens for comparison. Not having any at hand, however, he tried the effect of darkening some cotton-wool with lamp-black. Such a marked re-enforcement of the sound resulted that he was induced to try lamp-black alone.

About a teaspoonful of lamp-black was placed in a test-tube and exposed to an intermittent beam of sunlight. The sound produced was much louder than any heard before.

Upon smoking a piece of plate-glass, and holding it in the intermittent beam with the lamp-black surface towards the sun, the sound produced was loud enough to be heard, with attention, in any part of the room. With the lamp-black surface turned from the sun the sound was much feebler.

Mr. Tainter repeated these experiments for me immediately upon my return to Washington, so that I might verify his results.

† "Notes on Radiophony," *Comptes Rendus*, Dec, 6 and 13, 1880; Feb. 21 and 28, 1881. See, also, *Journal de Physique*, vol. x, p. 53.

‡ "Action of an Intermittent Beam of Radiant Heat upon Gaseous Matter." *Proc. Royal Society*, Jan. 13, 1881, vol. xxxi, p. 307.

§ "On the tones which arise from the intermittent illumination of a gas." See *Annalen der Phys. und Chemie*, *Jan.*, 1881, No. 1, p. 155.

‖ "On the Conversion of Radiant Energy into Sonorous Vibrations." *Proc. Royal Society*, March 10, 1881, vol. xxxi, p. 506.

†† On the 7th of January.

Upon smoking the interior of the conical cavity shown in Fig. 1, and then exposing it to the intermittent beam, with the glass lid in position as shown, the effect was perfectly startling. The sound was so loud as to be actually painful to an ear placed closely against the end of the hearing-tube.

The sounds, however, were sensibly louder when we placed some smoked wire gauze in the receiver, as illustrated in the drawing, Fig. 1.*

When the beam was thrown into a resonator, the interior of which had been smoked over a lamp, most curious alternations of sound and silence were observed. The interrupting disk was set rotating at a high rate of speed, and was then allowed to come gradually to rest. An extremely feeble musical tone was at first heard, which gradually fell in pitch as the rate of interruption grew less. The loudness of the sound produced varied in the most interesting manner. Minor re-inforcements were constantly occurring, which became more and more marked as the true pitch of the resonator was neared. When at last the frequency of interruption corresponded to the frequency of the fundamental of the resonator, the sound produced was so loud that it might have been heard by an audience of hundreds of people.

The effects produced by lamp-black seemed to me to be very extraordinary, especially as I had a distinct recollection of experiments made in the Summer of 1880 with smoked diaphragms, in which no such re-enforcement was noticed.

Upon examining the records of our past photophonic experiments we found in vol. vii, p. 57, the following note:

"Experiment V.—Mica diaphragm covered with lamp-black on side exposed to light.

"Result: distinct sound about same as without lamp-black.—*A. G. B. July 18th*, 1880.

"Verified the above, but think it somewhat louder than when used without lamp-black.—*S. T., July 18th*, 1880.

Upon repeating this old experiment we arrived at the same result as that noted. Little if any augmentation of sound resulted from smoking the mica. In this experiment the effect was observed by placing the mica diaphragm against the ear and also by listening through a hearing-tube, one end of which was closed by the diaphragm. The sound was found to be more audible through the free air when the ear was placed as near to the lamp-black surface as it could be brought without shading it.

At the time of my communication to the American Association I had been unable to satisfy myself that the substances which had become sonorous under the direct influence of intermittent sunlight were capable of reproducing the sounds of articulate speech under the action of an undulatory beam from our photophonic transmitter. The difficulty in ascertaining this will be understood by considering that the sounds emitted by thin diaphragms and tubes were so feeble that it was impracticable to produce audible effects from substances in these conditions at any considerable distance away from the transmitter; but it was equally impossible to judge of the effects produced by our articulate transmitter at a short distance away because the speaker's voice was directly audible through the air. The extremely loud sounds produced from lamp-black have enabled us to demonstrate the feasibility of using this substance in an articulating photophone in place of the electrical receiver formerly employed.

The drawing (Fig. 2*) illustrates the mode in which the experiment was conducted. The diaphragm of the transmitter (A) was only 5 centimetres in diameter, the diameter of the receiver (B) was also 5 centimetres, and the distance between the two was 40 metres, or 800 times the diameter of the transmitting diaphragm. We were unable to experiment at greater distances without

*See page 247 for illustrations.

a heliostat on account of the difficulty of keeping the light steadily directed on the receiver. Words and sentences spoken into the transmitter in a low tone of voice were audibly reproduced by the lamp-black receiver.

In Fig. 3* is shown a mode of interrupting a beam of sunlight for producing distant effects without the use of lenses. Two similarly-perforated disks are employed, one of which is set in rapid rotation while the other remains stationary. This form of interrupter is also admirably adapted for work with artificial light. The receiver illustrated in the drawing consists of a parabolic reflector, in the focus of which is placed a glass vessel (A) containing lamp-black or other sensitive substance, and connected with a hearing-tube. The beam of light is interrupted by its passage through the two slotted disks shown at B, and in operating the instrument musical signals like the dots and dashes of the Morse alphabet are produced from the sensitive receiver (A) by slight motions of the mirror (C) about its axis (D).

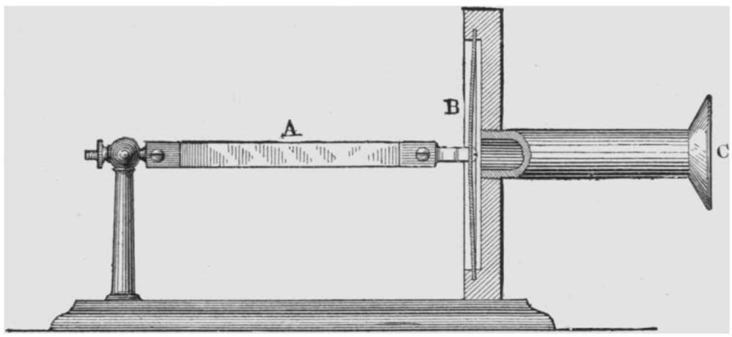


Fig. 5.

In place of the parabolic reflector shown in the figure, a conical reflector like that recommended by Prof. Sylvanus Thompson† can be used, in which case a cylindrical glass vessel would be preferable to the flask (A) shown in the figure.

In regard to the sensitive materials that can be employed, our experiments indicate that in the case of solids the physical condition and the color are two conditions that markedly influence the intensity of the sonorous effects. *The loudest sounds are produced from substances in a loose, porous, spongy condition, and from those that have the darkest or most absorbent colors.*

The materials from which the best effects have been produced are cotton-wool, worsted, fibrous materials generally, cork, sponge, platinum and other metals in a spongy condition, and lamp-black.

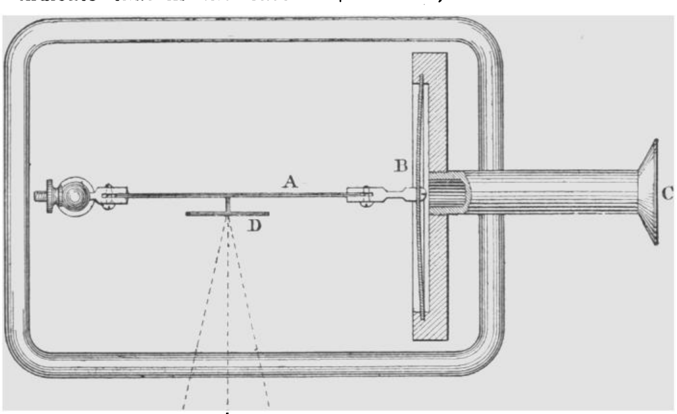


Fig. 6.

The loud sounds produced from such substances may perhaps be explained in the following manner: Let us consider, for example, the case of lamp-black—a substance which becomes heated by exposure to rays of all refrangibility. I look upon a mass of this substance as a sort of sponge, with its pores filled with air instead of water. When a beam of sunlight falls upon this mass the particles of lamp-black are heated, and consequently expand, causing a contraction of the air-spaces or pores among them.

Under these circumstances a pulse of air should be expelled, just as we would squeeze out water from a sponge.

The force with which the air is expelled must be greatly increased by the expansion of the air itself, due to contact with the heated particles of lamp-black. When the light is cut off the converse process takes place. The lamp-black particles cool and contract, thus enlarging the air spaces among them, and the enclosed air also becomes cool. Under these circumstances a partial vacuum should be formed among the particles, and the outside air would then be absorbed, as water is by a sponge when the pressure of the hand is removed.

I imagine that in some such manner as this a wave of condensation is started in the atmosphere each time a beam of sunlight falls upon lamp-black, and a wave of rarefaction is originated when the light is cut off. *We can thus understand how it is that a substance like lamp-black produces intense sonorous vibrations in the surrounding air, while at the same time it communicates a very feeble vibration to the diaphragm or solid bed upon which it rests.*

This curious fact was independently observed in England by Mr. Preece, and it led him to question whether, in our experiments with thin diaphragms, the sound heard was due to the vibration of the disk or (as Prof. Hughes had suggested) to the expansion and contraction of the air in contact with the disk confined in the cavity behind the diaphragm. In his paper read before the Royal Society on the 10th of March, Mr. Preece describes experiments from which he claims to have proved that the effects are wholly due to the vibrations of the confined air, and that the *disks do not vibrate at all.*

I shall briefly state my reasons for disagreeing with him in this conclusion:

1. When an intermittent beam of sunlight is focussed upon a sheet of hard rubber or other material, a musical tone can be heard, not only by placing the ear immediately behind the part receiving the beam, but by placing it against any portion of the sheet, even though this may be a foot or more from the place acted upon by the light.

2. When the beam is thrown upon the diaphragm of a "Blake Transmitter," a loud musical tone is produced by a telephone connected in the same galvanic circuit with the carbon button (A) Fig. 4.* Good effects are also produced when the carbon button (A) forms, with the battery (B), a portion of the primary circuit of an induction coil, the telephone (C) being placed in the secondary circuit.

In these cases the wooden box and mouth-piece of the transmitter should be removed, so that no air-cavities may be left on either side of the diaphragm.

It is evident, therefore, that in the case of thin disks a real vibration of the diaphragm is caused by the action of the intermittent beam, independently of any expansion and contraction of the air confined in the cavity behind the diaphragm.

Lord Rayleigh has shown mathematically that a to-and-fro vibration, of sufficient amplitude to produce an audible

*See page 247 for illustrations.

† Phil. Mag., April, 1881, vol. xi, p. 286.

* See page 248 for illustrations.

sound, would result from a periodical communication and abstraction of heat, and he says : " We may conclude, I think, that there is, at present no reason for discarding the obvious explanation that the sounds in question are due to the bending of the plates under unequal heating." (Nature, xxiii, p. 274). Mr. Preece, however, seeks to prove that the sonorous effects cannot be explained upon this supposition ; but his experimental proof is inadequate to support his conclusion. Mr. Preece expected that if Lord Rayleigh's explanation was correct, the expansion and contraction of a thin strip under the influence of an intermittent beam could be caused to open and close a galvanic circuit so as to produce a musical tone from a telephone in the circuit. But this was an inadequate way to test the point at issue, for Lord Rayleigh has shown (Proc. of Roy. Soc., 1877) that an audible sound can be produced by a vibration whose amplitude is *less than a ten-millionth of a centimetre*, and certainly such a vibration as that would not have sufficed to operate a "make-and-break contact" like that used by Mr. Preece. The negative results obtained by him cannot, therefore, be considered conclusive.

The following experiments (devised by Mr. Tainter) have given results decidedly more favorable to the theory of Lord Rayleigh than to that of Mr. Preece:

1. A strip (A), similar to that used in Mr. Preece's experiment was attached firmly to the centre of an iron diaphragm (B) as shown in Fig. 5, and was then pulled taut at right angles to the plane of the diaphragm. When the intermittent beam was focussed upon the strip (A), a clear musical tone could be heard by applying the ear to the hearing tube (C).

This seemed to indicate a rapid expansion and contraction of the substance under trial.

But a vibration of the diaphragm (B) would also have resulted if the thin strip (A) had acquired a to-and-fro motion, due either to the direct impact of the beam or to the expansion of the air in contact with the strip.

2. To test whether this had been the case an additional strip (D) was attached by its central point only to the strip under trial, and was then submitted to the action of the beam, as shown in Fig. 6.

It was presumed that if the vibration of the diaphragm (B) had been due to a *pushing force* acting on the strip (A), that the addition of the strip (D) would not interfere with the effect. But if, on the other hand, it had been due to the longitudinal expansion and contraction of the strip (A), the sound would cease, or at least be reduced. The beam of light falling upon the strip (D) was now interrupted as before by the rapid rotation of a perforated disk, which was allowed to come gradually to rest.

No sound was heard excepting at a certain speed of rotation, when a feeble musical tone became audible.

This result is confirmatory of the first.

The audibility of the effect at a particular rate of interruption suggests the explanation that the strip (D) had a normal rate of vibration of its own.

When the frequency of the interruption of the light corresponded to this, the strip was probably thrown into vibration after the manner of a tuning fork, in which case a to-and-fro vibration would be propagated down its stem or central support to the strip (A).

This indirectly proves the value of the experiment.

The list of solid substances that have been submitted to experiment in my laboratory is too long to be quoted here, and I shall merely say that we have not yet found one solid body that has failed to become sonorous under proper conditions of experiment.*

* Carbon and thin microscope glass are mentioned in my Boston paper as non-responsive, and powdered chlorate of potash in the communication to the French Academy, (Comptes Rendus, vol. xlc, p. 595.) All these substances have since yielded sounds under more careful conditions of experiment.

EXPERIMENTS WITH LIQUIDS.

The sounds produced by liquids are much more difficult to observe than those produced by solids. The high absorptive power possessed by most liquids would lead one to expect intense vibrations from the action of intermittent light, but the number of sonorous liquids that have so far been found is extremely limited, and the sounds produced are so feeble as to be heard only by the greatest attention and under the best circumstances of experiment. In the experiments made in my laboratory a very long test-tube was filled with the liquid under examination, and a flexible rubber-tube was slipped over the mouth far enough down to prevent the possibility of any light reaching the vapor above the surface. Precautions were also taken to prevent reflection from the bottom of the test-tube. An intermittent beam of sunlight was then focussed upon the liquid in the middle portion of the test-tube by means of a lens of large diameter.

RESULTS.

Clear water	No sound audible.
Water discolored by ink	Feeble sound.
Mercury	No sound heard.
Sulphuric ether*	Feeble, but distinct sound.
Ammonia	" " " "
Ammonio-sulphate of copper.	" " " "
Writing ink	" " " "
Indigo in sulphuric acid	" " " "
Chloride of copper*	" " " "

The liquids distinguished by an asterisk gave the best sounds.

Acoustic vibrations are always much enfeebled in passing from liquids to gases, and it is probable that a form of experiment may be devised which will yield better results by communicating the vibrations of the liquid to the ear through the medium of a solid rod.

EXPERIMENTS WITH GASEOUS MATTER.

On the 29th of November, 1880, I had the pleasure of showing to Prof. Tyndall in the laboratory of the Royal Institution the experiments described in the letter to Mr. Tainter from which I have quoted above, and Prof. Tyndall at once expressed the opinion that the sounds were due to rapid changes of temperature in the body submitted to the action of the beam. Finding that no experiments had been made at that time to test the sonorous properties of different gases, he suggested filling one test-tube with the vapor of sulphuric ether, (a good absorbent of heat,) and another with the vapor of bisulphide of carbon, (a poor absorbent,) and he predicted that if any sound was heard it would be louder in the former case than in the latter.

The experiment was immediately made, and the result verified the prediction.

Since the publication of the memoirs of Röntgen* and Tyndall† we have repeated these experiments, and have extended the inquiry to a number of other gaseous bodies, obtaining in every case similar results to those noted in the memoirs referred to.

The vapors of the following substances were found to be highly sonorous in the intermittent beam: Water vapor, coal gas, sulphuric ether, alcohol, ammonia, amylene, ethyl bromide, diethylamene, mercury, iodine, and peroxide of nitrogen. The loudest sounds were obtained from iodine and peroxide of nitrogen.

I have now shown that sounds are produced by the direct action of intermittent sunlight from substances in every physical condition (solid, liquid, and gaseous), and the probability is, therefore, very greatly increased that sonorousness, under such circumstances, will be found to be a universal property of matter.

*Ann. der Phys. und Chem., 1881, No. 1, p. 155.

†Proc. Roy. Soc., vol. xxxi, p. 307.

UPON SUBSTITUTES FOR SELENIUM IN ELECTRICAL RECEIVERS.

At the time of my communication to the American Association the loudest effects obtained were produced by the use of selenium, arranged in a cell of suitable construction, and placed in a galvanic circuit with a telephone. Upon allowing an intermittent beam of sunlight to fall upon the selenium a musical tone of great intensity was produced from the telephone connected with it.

But the selenium was very inconstant in its action. It was rarely, if ever, found to be the case, that two pieces of selenium (even of the same stick) yielded the same results under identical circumstances of annealing, etc. While in Europe last autumn, Dr. Chichester Bell, of University College, London, suggested to me that this inconstancy of result might be due to chemical impurities in the selenium used. Dr. Bell has since visited my laboratory in Washington, and has made a chemical examination of the various samples of selenium I had collected from different parts of the world. As I understand it to be his intention to publish the results of this analysis very soon, I shall make no further mention of his investigation than to state that he has found sulphur, iron, lead, and arsenic in the so-called "selenium," with traces of organic matter; that a quantitative examination has revealed the fact that sulphur constitutes nearly one per cent. of the whole mass; and that when these impurities are eliminated the selenium appears to be more constant in its action and more sensitive to light.

Prof. W. G. Adams* has shown that tellurium, like selenium, has its electrical resistance affected by light, and we have attempted to utilize this substance in place of

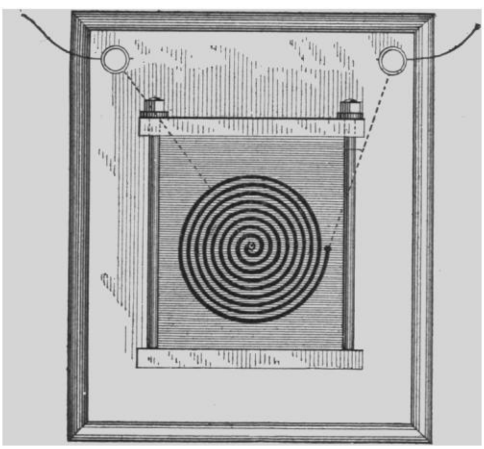


Fig. 7.

selenium. The arrangement of cell (shown in Fig. 7) was constructed for this purpose in the early part of 1880; but we failed at that time to obtain any indications of sensitiveness with a reflecting galvanometer. We have since found, however, that when this tellurium spiral is connected in circuit with a galvanic battery and telephone, and exposed to the action of an intermittent beam of sunlight, a distinct musical tone is produced by the telephone. The audible effectis much increased by placing the tellurium cell with the battery in the primary circuit of an induction coil, and placing the telephone in the secondary circuit.

The enormously high resistance of selenium and the extremely low resistance of tellurium suggested the thought that an alloy of these two substances might possess intermediate electrical properties. We have accordingly mixed together selenium and tellurium in different proportions, and while we do not feel warranted at the present time in making definite statements concerning the results, I may say that such alloys have proved to be sensitive to the action of light.

*Proc. Roy. Soc., vol. xxiv, p. 163.

It occurred to Mr. Tainter before my return to Washington last January that the very great molecular disturbance produced in lamp-black by the action of intermittent sunlight should produce a corresponding disturbance in an electric current passed through it, in which case lamp-black could be employed in place of selenium in an electrical receiver. This has turned out to be the case, and the importance of the discovery is very great, especially when we consider the expense of such rare substances as selenium and tellurium.

The form of lamp-black cell we have found most effec-

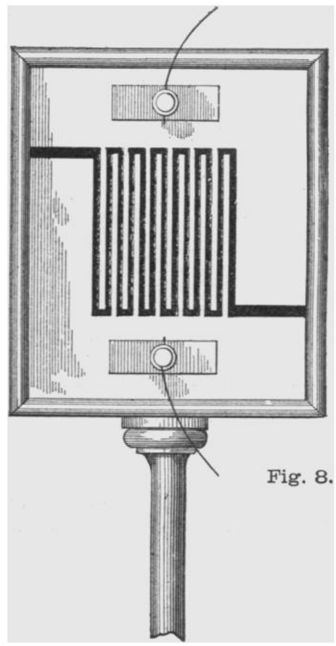


Fig. 8.

tive is shown in Fig. 8. Silver is deposited upon a plate of glass, and a zigzag line is then scratched through the film, as shown, dividing the silver surface into two portions insulated from one another, having the form of two combs with interlocking teeth.

Each comb is attached to a screw-cup, so that the cell can be placed in an electrical circuit when required. The surface is then smoked until a good film of lamp-black is obtained, filling the interstices between the teeth of the silver combs. When the lamp-black cell is connected with a telephone and galvanic battery, and exposed to the influence of an intermittent beam of sunlight, a loud musical tone is produced by the telephone. This result seems to be due rather to the physical condition than to the nature of the conducting material employed, as metals in a spongy condition produce similar effects. For instance, when an electrical current is passed through spongy platinum while it is exposed to intermittent sunlight, a distinct musical tone is produced by a telephone in the same circuit. In all such cases the effect is increased by the use of an induction coil; and the sensitive cells can be employed for the reproduction of articulate speech as well as for the production of musical sounds.

We have also found that loud sounds are produced from lamp-black by passing through it an intermittent electrical current; and that it can be used as a telephonic receiver for the reproduction of articulate speech by electrical means.

A convenient mode of arranging a lamp-black cell for

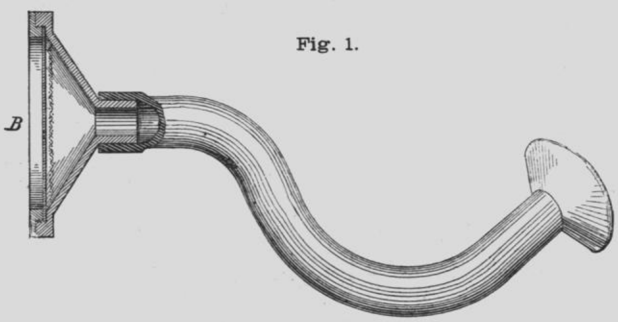


Fig. 1.

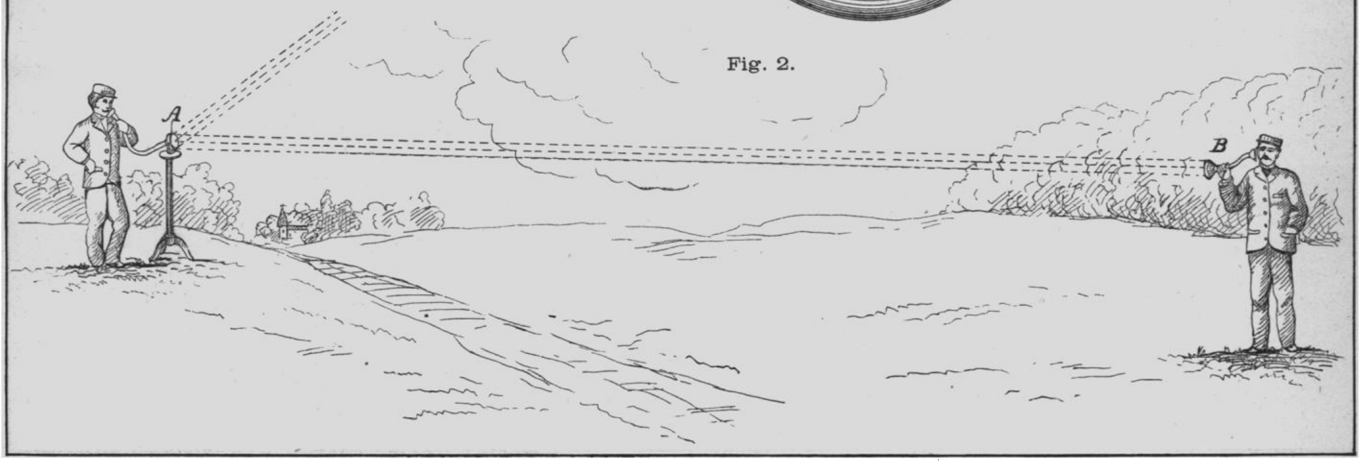


Fig. 2.

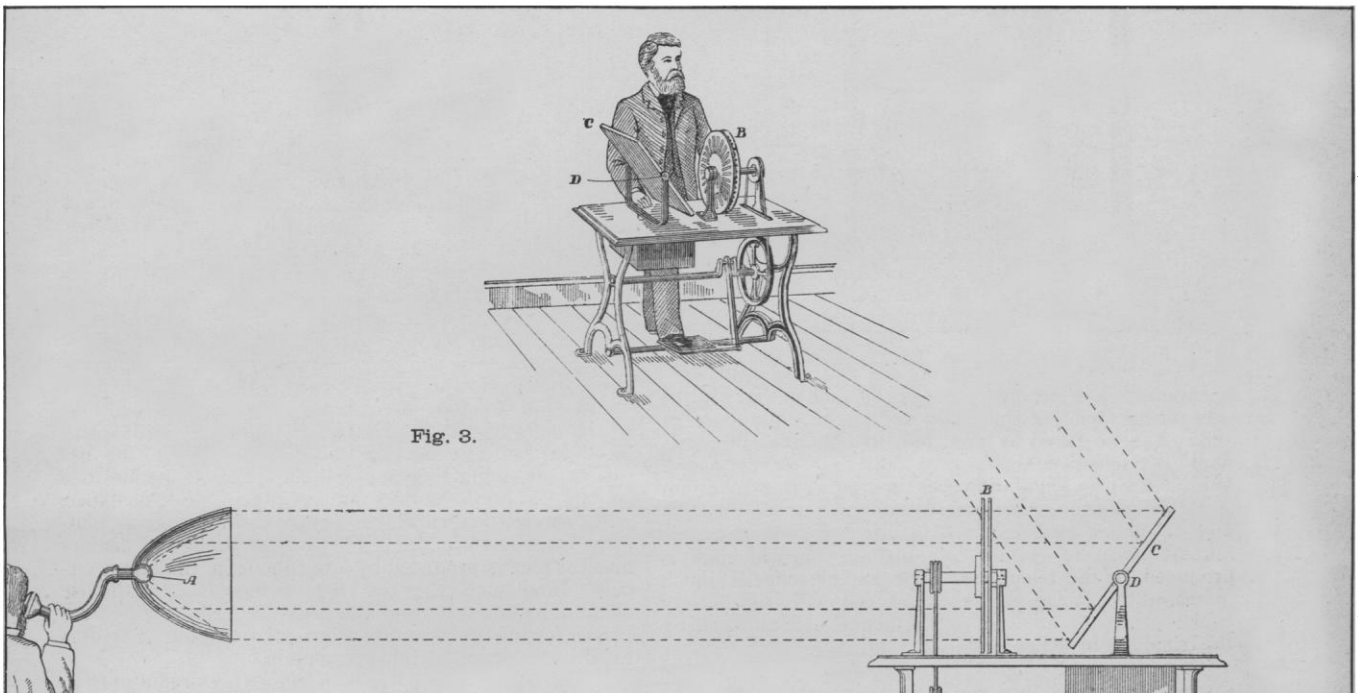


Fig. 3.

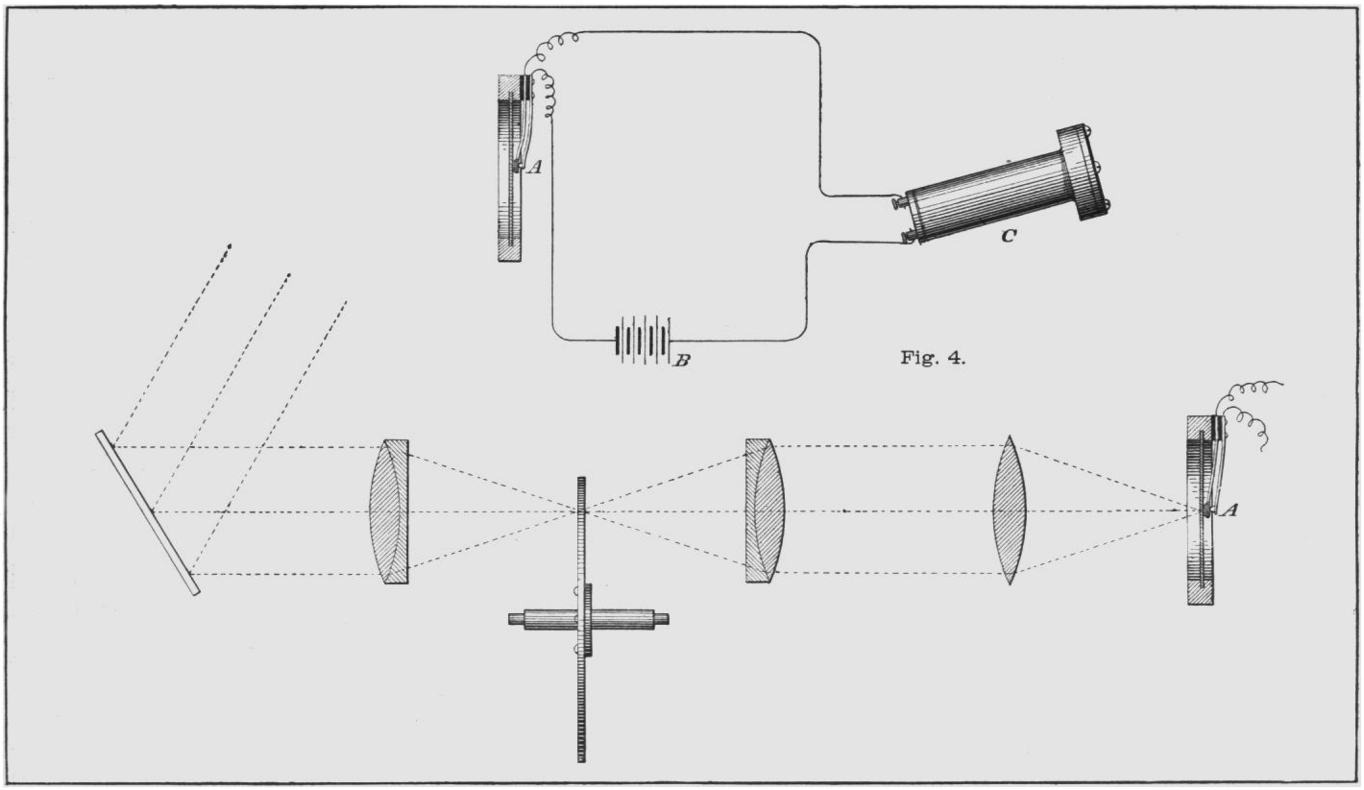


Fig. 4.

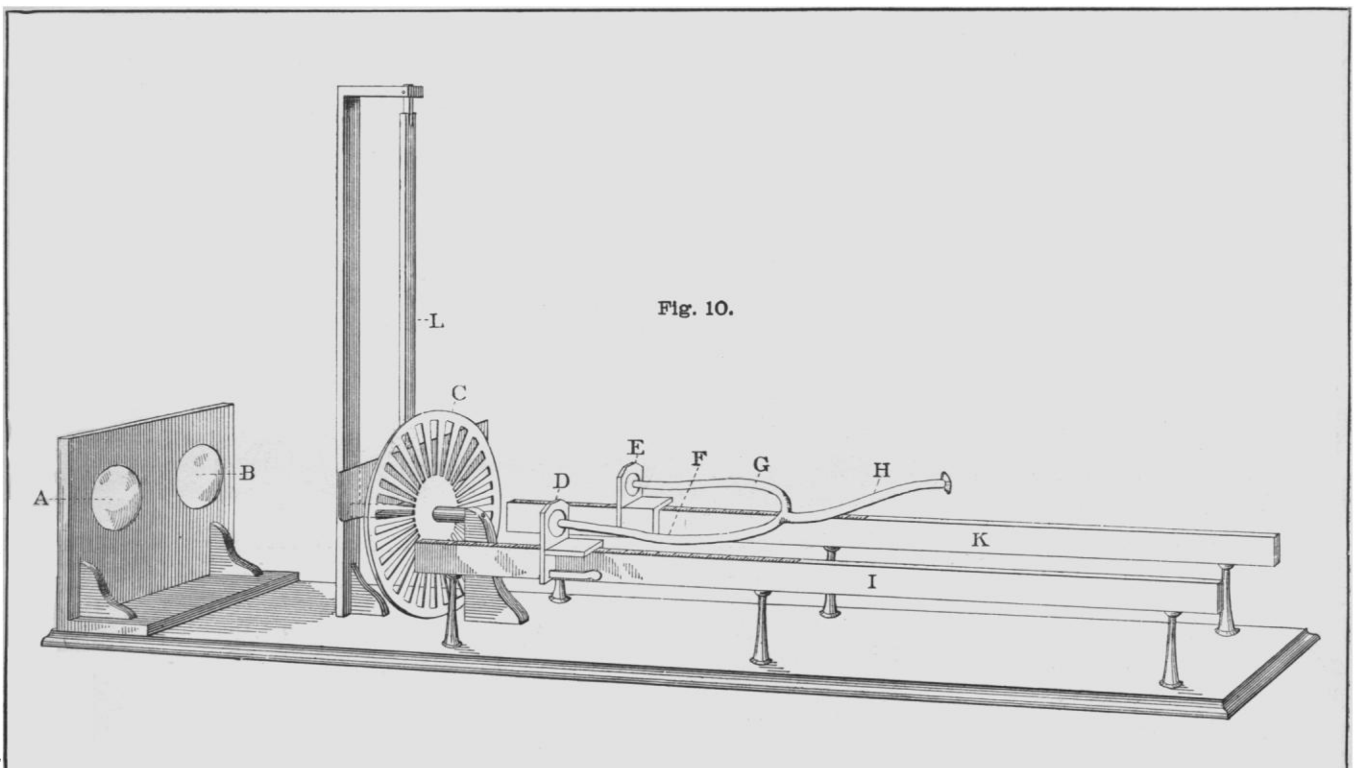


Fig. 10.

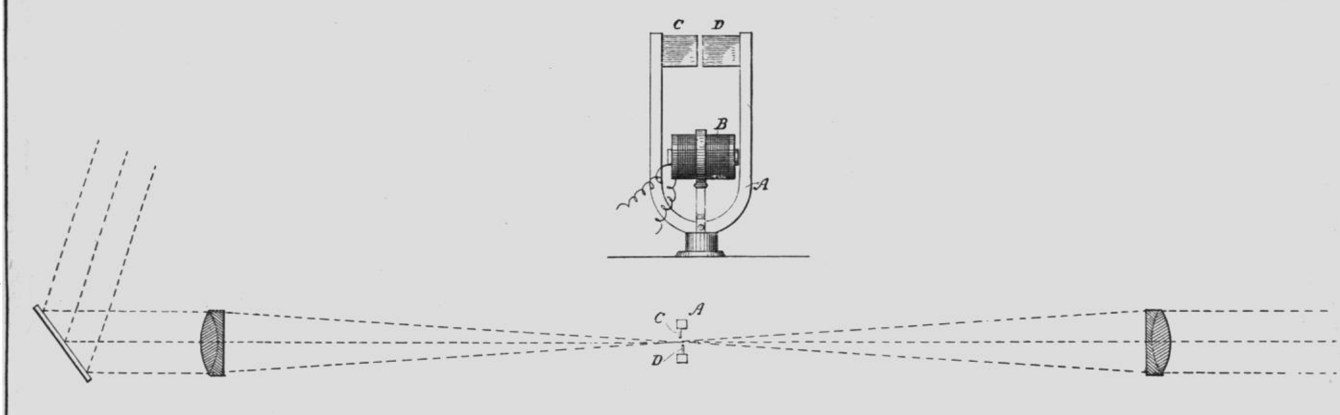


Fig. 11.

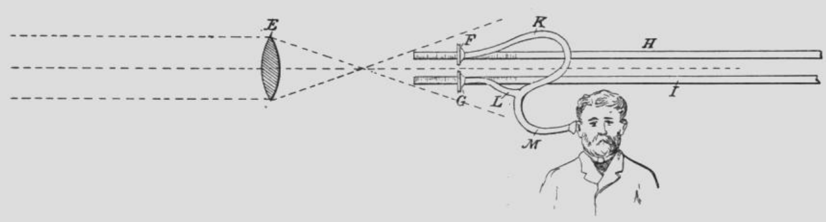
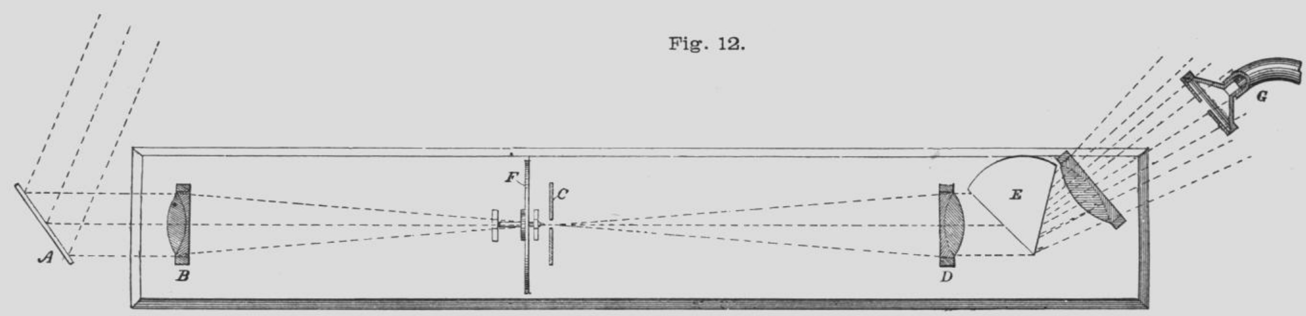


Fig. 12.



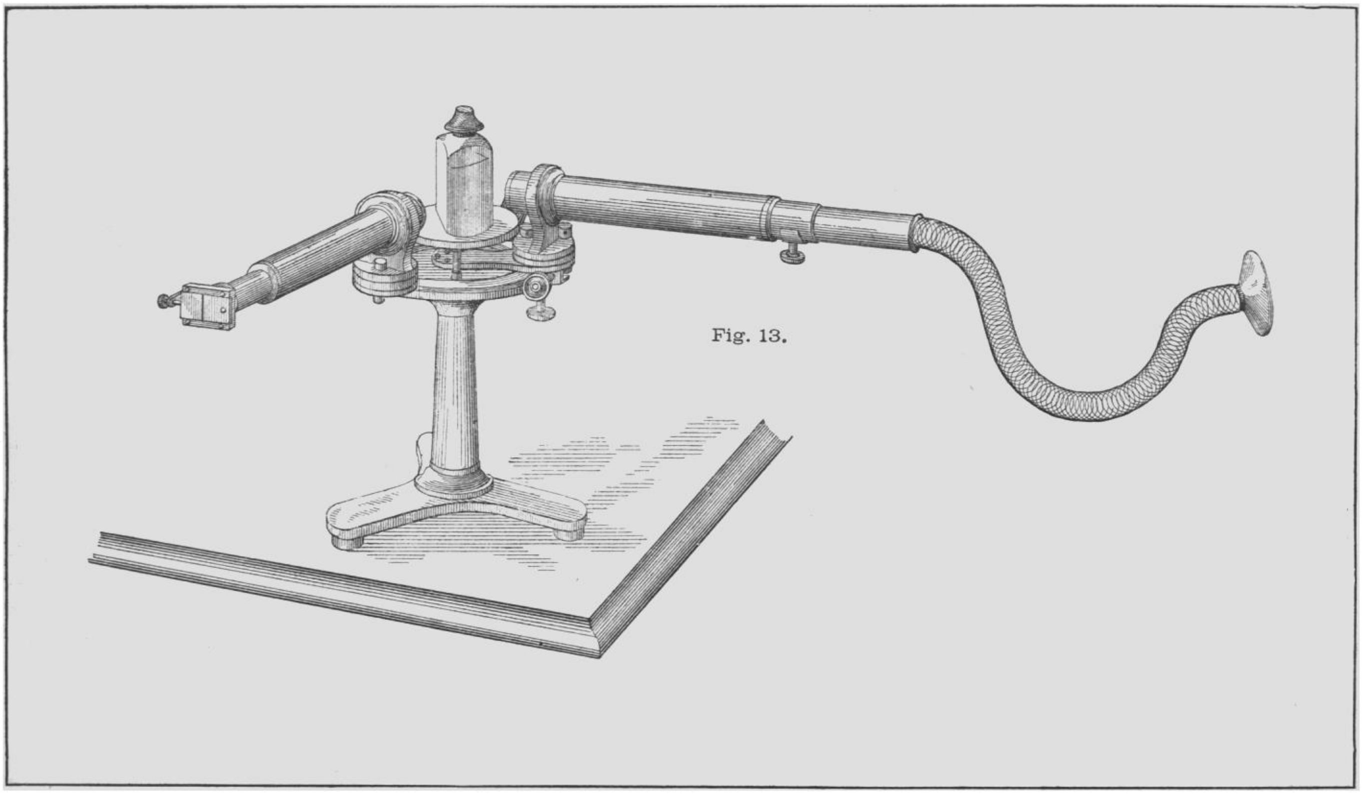
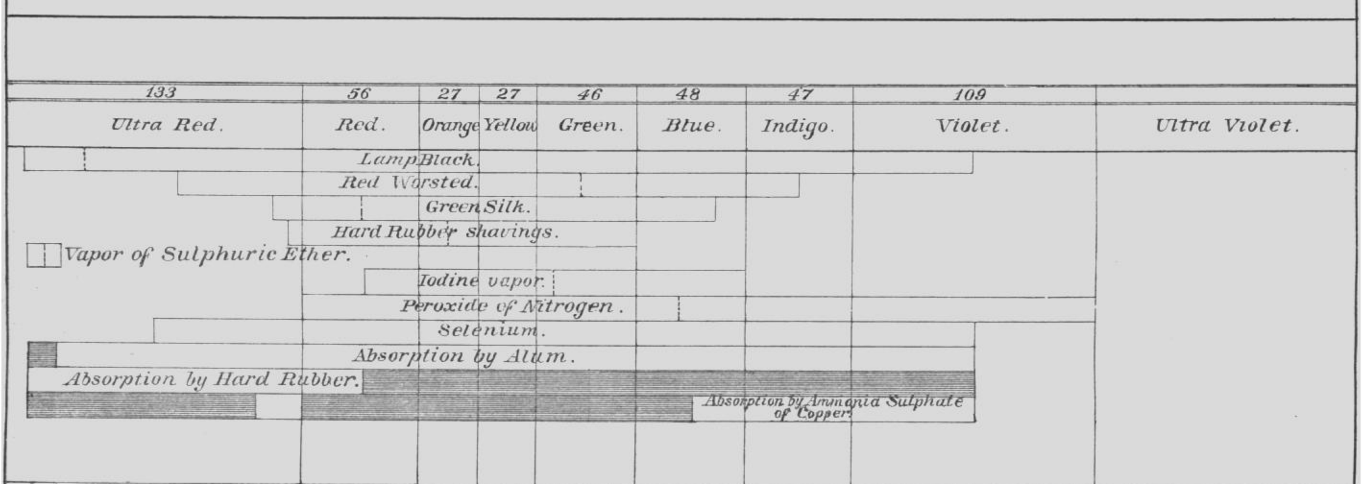


Fig. 13.

Fig. 14.


133
56
27
27
46
48
47
109
Ultra Red.
Red.
Orange
Yellow
Green.
Blue.
Indigo.
Violet.
Ultra Violet.
Lamp Black.
Red Worsted.
Green Silk.
Hard Rubber shavings.
Vapor of Sulphuric Ether.
Iodine vapor.
Peroxide of Nitrogen.
Selenium.
Absorption by Alum.
Absorption by Hard Rubber.
Absorption by Ammonia Sulphate of Copper.

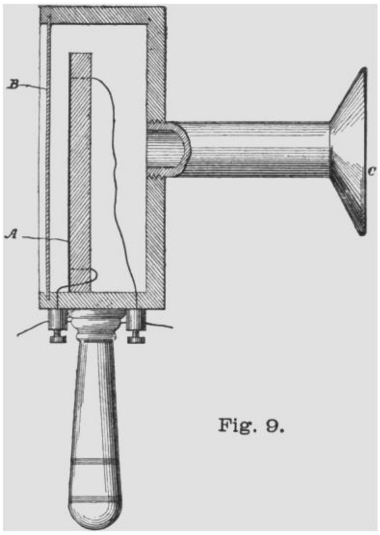


Fig. 9.

experimental purposes is shown in Fig. 9. When an intermittent current is passed through the lamp-black, (A) or when an intermittent beam of sunlight falls upon it through the glass plate (B) a loud musical tone can be heard by applying the ear to the hearing-tube (C). When the light and the electrical current act simultaneously, two musical tones are perceived, which produce beats when nearly of the same pitch. By proper arrangements a complete interference of sound can undoubtedly be produced.

UPON THE MEASUREMENT OF THE SONOROUS EFFECTS PRODUCED BY DIFFERENT SUBSTANCES.

We have observed that different substances produce sounds of very different intensities under similar circumstances of experiment, and it has appeared to us that very valuable information might be obtained if we could measure the audible effects produced. For this purpose we have constructed several different forms of apparatus for studying the effects, but as our researches are not yet complete, I shall confine myself to a simple description of some of the forms of apparatus we have devised.

When a beam of light is brought to a focus by means of a lens, the beam diverging from the focal point becomes weaker as the distance increases in a calculable degree. Hence, if we can determine the distances from the focal point at which two different substances emit sounds of equal intensity, we can calculate their relative sonorous powers.

Preliminary experiments were made by Mr. Tainter during my absence in Europe to ascertain the distance from the focal point of a lens at which the sound produced by a substance became inaudible. A few of the results obtained will show the enormous differences existing between different substances in this respect.

DISTANCE FROM FOCAL POINT OF LENS AT WHICH SOUNDS BECOME INAUDIBLE WITH DIFFERENT SUBSTANCES.

Zinc diaphragm	(polished)	1.51	m
Hard rubber diaphragm		1.90	"
Tin-foil	"	2.00	"
Telephone	" (Japanned iron)	2.15	"
Zinc	" (unpolished)	2.15	"
White silk,	(In receiver shown in Fig. 1.)	3.10	"
White worsted,	" " " "	4.01	"
Yellow worsted,	" " " "	4.06	"
Yellow silk,	" " " "	4.13	"
White cotton wool,	" " " "	4.38	"
Green silk,	" " " "	4.52	"
Blue worsted,	" " " "	4.69	"
Purple silk,	" " " "	4.82	"
Brown silk,	" " " "	5.02	"
Black silk,	" " " "	5.21	"
Red Silk,	" " " "	5.24	"
Black worsted,	" " " "	6.50	"
Lamp-black. In receiver the limit of audibility could not be determined on account of want of space. Sound perfectly audible at a distance of		10.00	"

Mr. Tainter was convinced from these experiments that this field of research promised valuable results, and he at once devised an apparatus for studying the effects, which he described to me upon my return from Europe. The apparatus has since been constructed and I take great pleasure in showing it to you to-day.

(1.) A beam of light is received by two similar lenses (A B, Fig. 10*), which bring the light to a focus on either side of the interrupting disk (C). The two substances, whose sonorous powers are to be compared, are placed in the receiving vessels (D E)—so arranged as to expose equal surfaces to the action of the beam—which communicate by flexible tubes (F G) of equal length, with the common hearing-tube (H). The receivers (D E) are placed upon slides, which can be moved along the graduated supports (I K). The beams of light passing through the interrupting disk (C), are alternately cut off by the swinging of a pendulum (L). Thus a musical tone is produced alternately from the substance in D and from that in E. One of the receivers is kept at a constant point upon its scale, and the other receiver is moved towards or from the focus of its beam until the ear decides that the sounds produced from D and E are of equal intensity. The relative positions of the receivers are then noted.

(2.) Another method of investigation is based upon the production of an interference of sound, and the apparatus employed is shown in Fig. 11.* The interrupter consists of a tuning-fork (A), which is kept in continuous vibration by means of an electro-magnet (B).

A powerful beam of light is brought to a focus between the prongs of the tuning-fork (A), and the passage of the beam is more or less obstructed by the vibration the opaque screens (C D) carried by the prongs of the fork.

As the tuning-fork (A) produces a sound by its own vibration, it is placed at a sufficient distance away to be inaudible through the air, and a system of lenses is employed for the purpose of bringing the undulating beam of light to the receiving lens (E) with as little loss as possible. The two receivers (F G) are attached to slides (H I) which move upon opposite sides of the axis of the beam, and the receivers are connected by flexible tubes of unequal length (K L) communicating with the common hearing-tube (M).

The length of the tube (K) is such that the sonorous vibrations from the receivers (F G) reach the common hearing-tube (M) in opposite phases. Under these circumstances silence is produced when the vibrations in the receivers (F G) are of equal intensity. When the intensities are unequal, a residual effect is perceived. In operating the instrument the position of the receiver (G) remains constant, and the receiver (F) is moved to or from the focus of the beam until complete silence is produced. The relative positions of the two receivers are then noted.

(3). Another mode is as follows: The loudness of a musical tone produced by the action of light is compared with the loudness of a tone of similar pitch produced by electrical means. A rheostat introduced into the circuit enables us to measure the amount of resistance required to render the electrical sound equal in intensity to the other.

* See pages 248 and 249 for illustrations.

(4.) If the tuning-fork (A) in Fig. 11 is thrown into vibration by an undulatory instead of an intermittent current passed through the electro-magnet (B), it is probable that a musical tone, electrically produced in the receiver (F) by the action of the same current, would be found capable of extinguishing the effect produced in the receiver (G) by the action of the undulatory beam of light, in which case it should be possible to establish an acoustic balance between the effects produced by light and electricity by introducing sufficient resistance into the electric circuit.

UPON THE NATURE OF THE RAYS THAT PRODUCE SONOROUS EFFECTS IN DIFFERENT SUBSTANCES.

In my paper read before the American Association last August and in the present paper I have used the word "light" in its usual rather than its scientific sense, and I have not hitherto attempted to discriminate the effects produced by the different constituents of ordinary light, the thermal, luminous, and actinic rays. I find, however, that the adoption of the word "photophone" by Mr. Tainter and myself has led to the assumption that we believed the audible effects discovered by us to be due entirely to the action of luminous rays. The meaning we have uniformly attached to the words "photophone" and "light" will be obvious from the following passage, quoted by my Boston paper:

"Although effects are produced as above shown by forms of radiant energy, which are invisible, we have named the apparatus for the production and reproduction of sound in this way the 'photophone' *because an ordinary beam of light contains the rays which are operative.*"

To avoid in future any misunderstandings upon this point we have decided to adopt the term "*radiophone,*" proposed by M. Mercadier, as a general term signifying an apparatus for the production of sound by any form of radiant energy, limiting the words *thermophone, photophone*, and *actinophone,* to apparatus for the production of sound by thermal, luminous, or actinic rays respectively.

M. Mercadier, in the course of his researches in radiophony, passed an intermittent beam from an electric lamp through a prism, and then examined the audible effects produced in different parts of the spectrum. (*Comptes Rendus,* Dec. 6th, 1880.)

We have repeated this experiment, using the sun as our source of radiation, and have obtained results somewhat different from those noted by M. Mercadier.

A beam of sunlight was reflected from a heliostat (A, Fig. 12*) through an achromatic lens, (B) so as to form an image of the sun upon the slit (C).

The beam then passed through another achromatic lens (D) and through a bisulphide of carbon prism (E), forming a spectrum of great intensity, which, when focussed upon a screen, was found to be sufficiently pure to show the principal absorption lines of the solar spectrum.

The disk-interrupter (F) was then turned with sufficient rapidity to produce from five to six hundred interruptions of the light per second, and the spectrum was explored with the receiver (G), which was so arranged that the lamp-black surface exposed was limited by a slit, as shown.

Under these circumstances sounds were obtained in every part of the visible spectrum, excepting the extreme half of the violet, as well as in the ultra-red. A continuous increase in the loudness of the sound was observed upon moving the receiver (G) gradually from the violet into the ultra-red. The point of maximum sound lay very far out in the ultra-red. Beyond this point the sound began to decrease, and then stopped so suddenly that a very slight motion of the receiver (G) made all the difference between almost maximum sound and complete silence.

*See page 249 for illustrations.

(2.) The lamp-blacked wire gauze was then removed and the interior of the receiver (G) was filled with red-worsted. Upon exploring the spectrum as before, entirely different results were obtained. The maximum effect was produced in the green at that part where the red worsted appeared to be black. On either side of this point the sound gradually died away, becoming inaudible on the one side in the middle of the indigo, and on the other at a short distance outside the edge of the red.

(3.) Upon substituting green silk for red worsted the limits of audition appeared to be the middle of the blue and a point a short distance out in the ultra-red. Maximum in the red.

(4.) Some hard-rubber shavings were now placed in the receiver (G). The limits of audibility appeared to be on the one hand the junction of the green and blue, and on the other the outside edge of the red. Maximum in the yellow. Mr. Tainter thought he could hear a little way into the ultra-red, and to his ear the maximum was about the junction of the red and orange.

(5.) A test-tube containing the vapor of sulphuric ether was then substituted for the receiver (G). Commencing at the violet end, the test-tube was gradually moved down the spectrum and out into the ultra-red without audible effect, but when a certain point far out in the ultra-red was reached a distinct musical tone suddenly made its appearance, which disappeared as suddenly on moving the test-tube a very little further on.

(6.) Upon exploring the spectrum with a test-tube containing the vapor of iodine the limits of audibility appeared to be the middle of the red and the junction of the blue and indigo. Maximum in the green.

(7.) A test-tube containing peroxide of nitrogen was substituted for that containing iodine. Distinct sounds were obtained in all parts of the visible spectrum, but no sounds were observed in the ultra-red.

The maximum effect seemed to me to be in the blue. The sounds were well marked in all parts of the violet, and I even fancied that the audible effect extended a little way into the ultra-violet, but of this I cannot be certain. Upon examining the absorption spectrum of peroxide of nitrogen it was at once observed that the maximum sound was produced in that part of the spectrum where the greatest number of absorption lines made their appearance.

(8.) The spectrum was now explored by a selenium cell, and the audible effects were observed by means of a telephone in the same galvanic circuit with the cell. The maximum effect was produced in the red. The audible effect extended a little way into the ultra-red on the one hand and up as high as the middle of the violet on the other.

Although the experiments so far made can only be considered as preliminary to others of a more refined nature, I think we are warranted in concluding that *the nature of the rays that produce sonorous effects in different substances depends upon the nature of the substances that are exposed to the beam, and that the sounds are in every case due to those rays of the spectrum that are absorbed by the body.*

THE SPECTROPHONE.

Our experiments upon the range of audibility of different substances in the spectrum have led us to the construction of a new instrument for use in spectrum analysis, which was described and exhibited to the Philosophical Society of Washington last Saturday.* The eye-piece of a spectroscope is removed, and sensitive substances are placed in the focal point of the instrument behind an opaque diaphragm containing a slit. These substances are put in communication with the ear by means of a hearing tube, and thus the instrument is converted into a veritable "spectrophone" like that shown in Fig. 13.†

* Proc. of Phil. Soc. of Washington, April 16, 1881.

†See page 250 for illustrations.

Suppose we smoke the interior of our spectrophonic receiver, and fill the cavity with peroxide of nitrogen gas. We have then a combination that gives us good sounds in all parts of the spectrum (visible and invisible), except the ultra-violet. Now, pass a rapidly-interrupted beam of light through some substance whose absorption spectrum is to be investigated, and bands of sound and silence are observed upon exploring the spectrum, the silent positions corresponding to the absorption bands. Of course, the ear cannot for one moment compete with the eye in the examination of the visible part of the spectrum; but in the invisible part beyond the red, where the eye is useless, the ear is invaluable. In working in this region of the spectrum, lamp-black alone may be used in the spectrophonic receiver. Indeed, the sounds produced by this substance in the ultra-red are so well marked as to constitute our instrument a most reliable and convenient substitute for the thermo-pile. A few experiments that have been made may be interesting.

(1.) The interrupted beam was filtered through a saturated solution of alum.

Result: The range of audibility in the ultra-red was slightly reduced by the absorption of a narrow band of the rays of lowest refrangibility. The sounds in the visible part of the spectrum seemed to be unaffected.

(2.) A thin sheet of hard rubber was interposed in the path of the beam.

Result: Well-marked sounds in every part of the ultra-red. No sounds in the visible part of the spectrum, excepting the extreme half of the red.

These experiments reveal the cause of the curious fact alluded to in my paper read before the American Association last August—that sounds were heard from selenium when the beam was filtered through both hard rubber and alum at the same time. (See table of results in Fig. 14.*)

(3.) A solution of ammonio-sulphate of copper was tried.

Result: When placed in the path of the beam the spectrum disappeared, with the exception of the blue and violet end. To the eye the spectrum was thus reduced to a single broad band of blue-violet light. To the ear, however, the spectrum revealed itself as two bands of sound with a broad space of silence between. The invisible rays transmitted constituted a narrow band just outside the red.

I think I have said enough to convince you of the value of this new method of examination, but I do not wish you to understand that we look upon our results as by any means complete. It is often more interesting to observe the first totterings of a child than to watch the firm tread of a full-grown man, and I feel that *our* first footsteps in this new field of science may have more of interest to you than the fuller results of mature research. This must be my excuse for having dwelt so long upon the details of incomplete experiments.

I recognize the fact that the spectrophone must ever remain a mere adjunct to the spectroscope, but I anticipate that it has a wide and independent field of usefulness in the investigation of absorption spectra in the ultra-red.

*See page 250 for illustrations.

CONTRIBUTIONS TO COMPARATIVE PSYCHOLOGY.

By S. V. Clevenger, M. D.

I. INSTINCT AND REASON.

In St. George Mivart's recent work, "The Cat," Chap. XI treats of the Psychology of that animal. Amidst the usual ambiguity to be found wherever such subjects are treated, Mivart occasionally formulates his views. On page 369 his words admit of no other interpretation than an acknowledgement that instinct is nearly, though not quite pure automatism. The possession of reason by the cat is at first evasively dealt with, and finally on page 373, flatly denied. Mivart finds fault with Herbert Spencer's views as to instinct: "According to Mr. Spencer it is a higher development of reason which it has replaced, owing to the establishment of a more perfect adjustment of inner relations to outer relations than exists where mere reason is concerned." That opinion of Spencer's is one of the many which deserves to be rescued from the oblivion his involved style threatens to inflict upon the mass of his writings. From pure morphological and histological observations I have been led to the conclusions at which Spencer arrives by a wholly different route. The nervous system is a net-work of conducting substance interrelating the units of the animal body.

In an article by Spitzka ("Insane Delusions" page 34, *Journal Nervous and Mental Disease*, January, 1881), occur the following words: "In fact I should, if asked to point to the chief factor on which the higher powers of the human brain depend, lay less stress on the cortical development as such, than in the immense preponderance of the white substance due to the massive associating tracts."

Automaticity created by unvarying persistence of impressions resulting in certain definite movements, whether occurring through heredity, or during the lifetime of the individual (as proficiency in piano playing, etc.), has, for its material substratum, absolute definiteness of association of those parts which the nervous system connects; thus, regarded as a colony, the component individuals of the organism are brought into thorough automatic relationship with one another, and to that part of the environment to which the organism responds instinctively.

On the other hand reason is represented by the disconnected, shifting, short and long nerve fibres, as the arcuate of the cerebrum, not as yet assigned to any definite location. Reason thus is the struggle toward automatism. Instinct is the outcome of the struggle. Broadly viewing the higher nervous organization of animals there is a perpetual tendency to the establishment of nerve routes which would eventuate in handing over perfect control of every function to the highest nerve system. Spitzka expresses this (Architecture of the Brain, page 649 J. N. & M. D. Oct. 1879): "With the development of these highest projection fibres, the cerebral hemispheres gradually encroached on the independency of the lower ganglia, until in its maximal development as found in man, it resembles a great empire which holds a number of tributary states in sway under a common powerful rule. The automatical unity now attained, finds its parallel psychical culmination in that more perfect consciousness of the *ego*, which is peculiar to man." There is nothing debatable about this tendency on the part of the nervous system; the greater relative masses of the longitudinal and transverse associating tracts in the spinal cords, spinal and cerebro-spinal nerves and brains of all animals, in proportion to their reasoning and instinctive abilities, point to a prevailing law which seeks the reduction of all animal movements to the simplest mechanical methods. A corollary from instinct being perfected reason, would be that the salvation of reason to the race depended upon the vicissitudes and shifting circumstances with which we are surrounded, amounting to rescue from the fate mentioned by Wallace in degradation through parasitism. DeQuincey calls the human brain a palimpsest. In old age new tissues of any kind are formed with difficulty, new routes in the brain strive in vain for establishment; in senility the nervous tracts established in youth, and upon which all subsequent associations are founded, are the last to suffer disintegration, hence youthful recollections become at this time more vivid.

FURTHER NOTES ON THE BRAIN OF THE SAUROPSIDA.

By E. C. Spitzka, M. D.

1. A most notable feature of the cerebral hemispheres of such reptiles as the Alligator, Iguana and sea-turtle is the absence of a proper choroid plexus in the lateral ventricle. This is the more remarkable as in the amphibia, the choriod plexus is very well developed. The sea-turtle has a few vascular coils protruding into the lateral ventricle at its posterior portion; nothing of the kind can be identified in the Iguana or in birds.

2. On removing the inner cerebral wall of an Alligator's hemisphere it can be seen that the Corpus Striatum is continued into the pedicle of the olfactory bulb, as a distinct prominence. In fact the substance of the pedicle is in the main a continuation of the Corpus Striatum and of the basilar part of the hemisphere, the dorso-lateral cortex becoming attenuated to a mere film on entering that structure. The lumen of the pedicle is a continuation of that recess of the lateral ventricle which undermines the mesal side of the root of the Corpus Striatum.

3. The Corpus Striatum is relatively more massive in the Sauropsida, than in any other animal group. It reaches its maximum in birds, where also the lateral ventricle is most reduced. It seems as if a secondary fusion must occur, as explaining the apparent obliteration noted in the latter group.

4. A careful study of the structure designated as the anterior commissure of the reptile's brain has failed to convince me that this structure is to be considered as the homologue of the same commissure in the mammalian brain. So far I am inclined to consider it as representing the Corpus Callosum, at least in part. Its fibres are medullated.

5. The inner face of the hemispheric wall is finely striated; this is due to the fasciculation of the nerve fibres lying subjacent to the ventricle; they correspond to the Corona radiata.

6. It is not difficult to see that the greater part of the cerebral surface, that is, the entire basilar and more than half of its lateral aspect is the representative of what in the mammalia is the least voluminous and functionally the least important portion, namely of the Island of Reil and the præperforate region. In some reptiles (Chelydra, Boa) these two districts or their homologues are demarcated from each other by a shallow sulcus. The area homologous with the Island of Reil, corresponds pretty accurately to the base of the Corpus Striatum; the other, represented in mammals by the *Substantia perforata anterior* is a bodily continuation of the thalamic halves, a marked constriction separates them from the thalami proper, on the dorsal surface. Perhaps they constitute a species of prothalamus.

There remains then as the representative of the convoluted portion of the cerebral hemispheres of the placental mammalia, merely the delicate thin walled portion of the reptilian cerebrum. It is here where the pyramidal nerve cells are found in the best development. In the tenuity of the subjacent nerve layer, it closely resembles the hemispheric wall of the mammalian embryo.

7. There are two varieties of cerebelli found in the Sauropsida; to these might be added a third or fundamental type from which the other or divergent types may be derived.

The fundamental type is found in serpents and apodal lacertians, as well as in Chelonia of a low type (Boa, Bascanion, Pseudopus, Chelydra). Here the cerebellum is a mere lip covering the entrance to the mesencephalic ventricle, as in the Amphibia, and in embryos.

The second type is found in the higher Chelonia (Cistudo, Naunemys, Calemys, Thalassochelys) and the Crocodilia (Alligator). Here the lip has become inflated, and extends like a hollow hood directly backwards over the fourth ventricle. It corresponds in its best development to nothing so much as to a baseball cap. This resemblance is heightened by the presence in the Alligator and Thallassochelys of a distant rim. I have found, in an individual of Cistudo, the Cerebellar cap dented from above, and turned inside out, as it were; the individual had suffered prolonged starvation.

The third variety is found in lacertians (Iguana) and birds (Struthio, Aro, Trichoglossus, Gallus, Columba, Phœnicopterus, etc). Here the cerebellar lip creeps up, as it were, on the posterior declivity of the optic (and post optic) lobes, firmly tied down to these by the arachnoid. In birds the lip becomes reflected from the highest point, and descends backwards.

The highest form of the second variety is found in the Alligator, where in the adult and in larger specimens, though not in the one or two-year-olds, there are distinct transverse sulci. In the sea-turtle an indication of transverse sulci is observed in hardened specimens; they may be artifacts, however.

8. An important feature of the reptilian brain are the lateral eminences of the Oblongata, which, from their connection with the eighth pair of cranial nerves, merit the designation of *eminentiæ acusticæ*. A reliquary fragment in the mammalia constitutes the Fasciola cinerea. But the greater portion of this, in reptiles (Alligator, Iguana) exceedingly complicated body seems to be a sort of herald of a higher cerebellar development, and the very similar lateral bodies of the human embryonic Oblongata appear to be swallowed up in the cerebellar mass. Future research must determine whether the *nuclei dentati* are derivable from these masses or whether some of the lesser cerebellar lobules monopolize them. In the Alligator they closely simulate cerebellar *folia*, and consist of gray and white substance. It is from them that arises the *eminentia transversa ventriculi quarti* so well developed in the Iguana and Alligator. In the latter the acoustic convolvuli are in morphological connection with the lateral kink of the cerebellum.

9. On comparing a series of animals beginning with the Amphibia, passing thence to the Sauropsida and ending with the mammalia, we find that there is this close correspondence to a series of mammalian embryonic and fœtal brains, that while in the lowest types the nerve fibres of the spinal cord are well provided with *myelin*, and the Oblongata presents the same maturity of structure, that it is only in higher types that the Cerebellum and Mesencephalon show the same or an approximate histological advance, which involves the Thalamus and Cerebrum in their entity only in the very highest types. This is an important confirmation of the laws laid down by Flechsig and Meynert.

ASTRONOMY.

THE MORRISON OBSERVATORY.

The Morrison Observatory—the gift of Miss Morrison, a former resident of Glasgow—was built at Glasgow, Missouri, in 1875. The building is well adapted to the purpose it is intended to serve, and was constructed under the supervision of Prof. C. W. Pritchett, who consulted several of the leading astronomers of the country in preparing his plans.

The position of the observatory is, latitude, 39° 16′ 16.8″ north. Longitude 1^h 3^m 5.93^s west of Washington. The latitude was obtained from observations recently made with the Transit Circle, and discussed by Prof. H.S. Pritchett; the longitude from an exchange of signals made with the United States Naval Observatory in 1880.

For instrumental equipment, the Morrison Observatory possesses one of Clark's finest 12¼ equatorials. It is of 17 feet focal length, and has already been the means of discovering a number of faint double stars. In 1877 and again in 1879, a large number of observations of the satellites of Mars were obtained. *Mimas* has been ob-

served on at least three occasions, and has been suspected, without being positively identified, a much larger number of times.

The Transit Circle was made by Troughton and Simms, London, in 1876 and was mounted in 1877. The construction of the instrument and the method of mounting are quite similar to the instruments in use at Greenwich, and Harvard College Observaory.

The telescope has a clear aperture of 6 inches, and a focal length of 6 feet 4 inches. The axis is cast in a single piece, into which fit the steel pivots, 3.50 inches in diameter. The Y's are of gun metal, and their bearing surfaces 2.50 inches long, 0.74 inches wide. The piers are of iron, and are firmly bolted to heavy stone caps which rest upon brick foundations. The circles are 24 inches in diameter, divided to 5′, and read by four microscopes each.

The reticule in the focus of the telescope carries 15 vertical and 5 horizontal threads—the vertical threads being all carried by the Right Ascension micrometer screw, and the horizontal threads by the declination screw. There are no fixed threads in the field.

The Transit Circle is furnished with two collimators having object glasses of 4 ft. 3 in. focal length and 4.33 in. aperture. The distance between the bearing points of the collimator Y's is 3 ft. 10 in. In the focus of each collimator are fixed two close vertical threads (about 5.3″ apart) and one horizontal thread. In the ordinary time observations it is customary to observe for collimation immediately before the observations of star transits, and then set the micrometer so as to destroy the error in collimation.

The Standard Sidereal Clock of the Observatory is Frodsham No. 1369. It was mounted in 1877, and has been running for two years past on a very small and constant rate.

In addition to these instruments, the Observatory is furnished with an excellent 4-in. Clark Comet Seeker, an Altazimuth by Gasella, and the usual barometers, thermometers, etc.

The work now being carried on is chiefly equatorial, and may be divided into two parts, as follows:

1. Double Star Work. A list consisting chiefly of binaries which have been neglected for some years (some of them for ten or twenty, or even thirty years) and will well repay observation. Besides these, a selected list of Burnham's stars, which are suspected of binarity, or which are quite new and have not been observed. Most of these stars are in the southern sky, and including the list for personal equation, will make a total of about 500 doubles. This work is well under way and will probably be concluded within a year.

2. The second part of the equatorial work consists of observations, descriptive and micrometric, upon planets and their satellites, and includes a series of observations extending over several years, upon the satellites of Saturn, and observations upon the red spot of Jupiter since its discovery at Glasgow in 1878.

With the Meridian Circle, no work is done beyond the ordinary observations for time.

The Time-Service of the Observatory, inaugurated within the past year by Prof. H. S. Pritchett, has met with well deserved success, and its value is fully appreciated by the people of the State. Two time balls are dropped by the Observatory clock—one in St. Louis and one in Kansas City—and the clock signals are regularly distributed over a large and constantly increasing area. Owing to its position—almost exactly one hour west of Washington—the Morrison Observatory will doubtless be largely depended upon in regulating the time of the Mississippi Valley, if any of the schemes for "Uniform Time" which have recently been proposed are ever adopted.

Though so well equipped instrumentally, Morrison Observatory, like many a similar institution of longer standing, is sadly crippled for want of funds: its income being barely sufficient for the support of a director without assistance. It is greatly to be regretted that one of the most promising observatories in the country should be thus curtailed in its usefulness, merely for want of proper financial support. W. C. W.

DISCOVERY OF AN ASTEROID.

The Smithsonian Institution has received from M. Foerster, of Berlin, the announcement of the discovery by M. Palisa, at Pola, on the 20th of May, 1881, of a planetoid of the thirteenth magnitude, in

R. A.	15h	3m
Dec.	—23°	2′

with a daily motion of 8^{m} *north.*

CORRESPONDENCE.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. No notice is taken of anonymous communi cations.*]

LOCUSTS AND SUN SPOTS.

To the Editor of "SCIENCE:"

SIR: It may concern some of your readers to know that I have just made the interesting discovery, that the multiplication and migration of the Rocky Mountain Locust (*Caloptenus spretus*), has been hitherto in exact agreement with the minima of Wolf's sun spot cycles as given (Mem. As. Soc. vols. XLII and XLIII), and its decrease has as nearly accorded with the maxima, there not being a year's difference. On European areas, it may be remarked, insect migration but *rarely agrees* with these maxima and minima, the chief periods being obtainable by counting the elevens since 1846. There likewise exists this marked difference, in that while the American locust spreads to the east and west of south, European migrants come north and east.

It would be important to determine the multiplication of the Corn Weevils in relation to the sun spots. Cannot the trade keep diaries? As the more destructive kind comes from the tropic, the minimum period should be dreaded. A. H. SWINTON.

GUILDFORD, ENG., *May,* 1881.

THE VIEWS OF DR. HOLMES UPON THE PROPOSED REVISION MODIFICATIONS OF ANATOMICAL NOMENCLATURE.

We are permitted to publish the following letter from Oliver Wendell Holmes to Professor B. G. Wilder respecting the articles on "Anatomical Nomenclature" which appeared in Nos. 38 and 39 of this journal. It may not be generally known to our readers that "The Autocrat of the Breakfast-table" has been for many years the Professor of Anatomy in the Harvard Medical School. BOSTON, May 3, 1881.

Dear Dr. Wilder:

I have read carefully your papers on Nomenclature. I entirely approve of it as an *attempt*, an attempt which I hope will be partially successful, for no such sweeping change is, I think, ever adopted as a whole. But I am struck with the reasonableness of the system of changes you propose, and the fitness of many of the special terms you have suggested.

The last thing an old teacher wants is, as you know full well, a new set of terms for a familiar set of objects. It is hard instructing ancient canine individuals in new devices. It is hard teaching old professors new tricks. So my approbation of your attempt is a *sic vos non vobis* case so far as I am concerned. There is one term which I do not quite fancy, *pero,* which you couple with *pes* in naming the rhinencephalic lobe. I should prefer the old term *bulbus* with *theca* unless there is some objection I do not see.

What you have to do is to keep agitating the subject,

to go on training your students to the new terms—some of which you or others will doubtless see reasons for changing—to improve as far as possible, fill up blanks, perhaps get up a small manual in which the new terms shall be practically applied, and have faith that sooner or later the best part of your innovations will find their way into scientific use. The plan is an excellent one, it is a new garment which will fit Science well, if that capricious and fantastic and old-fashioned dressing lady can only be induced to try it on.

Always very truly yours,
O. W. HOLMES.

A CURIOUS EGG.

E. E. BARNARD.

One of my hens of the "Dominico" breed is accountable for the presence to-day of a most remarkable egg, which was found in the hen's nest. This singular object measured about three inches in its longest diameter, a round oval in shape, not like the ordinary egg with a large and a small end. The shell was thin and soft to the touch, resembling the "skin" that is found inside an eggshell. Pressing on one end of the egg, a hard object was felt inside the shell. Opening the egg, by cutting with a sharp knife, two eggs were found, one perfect with a hard shell, slightly smaller than the ordinary egg, the other perfect in every respect, save that it possessed no shell. The egg with the shell was enclosed in the white of the other. These two eggs occupied the two ends of the original shell. Upon opening the one with the hard shell it was found to be perfect. Putting the two eggs in separate cups, the one which had the hard shell was slightly smaller and its yolk of a pale yellow; the yolk of the other was somewhat deeper in color.

Here we have a rare phenomenon; first a large egg with slightly soft shell; inside this two eggs, one perfect in a hard shell, the other without shell but otherwise perfect.

NASHVILLE, Tenn., *May* 9.

BOOKS RECEIVED.

A MEMORIAL OF JOSEPH HENRY. Published by order of Congress, Washington, 1880.

The present volume presents in a handsome and convenient form the historical facts relating to the career of Professor Joseph Henry, and a record of the various ceremonies and memorial exercises celebrated after his death in honor to his memory.

The memorial exercises at the Capital include addresses by President Garfield, Hannibal Hamlin, Robert E. Withers, Professor Asa Gray, William B. Rogers, General Sherman and others.

The concluding words of President Garfield's address may well be quoted as conveying the general esteem in which Professor Henry was held by all who knew him. "Remembering his great career as a man of science, as a man who served his Government with singular ability and faithfulness, who was loved and venerated by every circle, who blessed with the light of friendship the worthiest and the best, whose life added new lustre to the glory of the human race, we shall be most fortunate, if ever in the future, we see his like again."

NOTES.

RECENT experiments by M. Grehaut, prove that the quantity of carbonic acid exhaled by any one individual of an animal species is about constant. Fifty litres of air passed through the lungs of a dog, 9kg. weight, yielded 2.747 gr. of CO_2. Eight days after the experiment was repeated, and the CO_2 was 2.810 gr. In man, the same volume of air circulating through the lungs, receives 3.333 gr. of CO_2. Irritations and inflammations of the respiratory mucous membrane (*e. g.* through inhaling sulphurous acid), considerably decrease the exhalation of CO_2. The gas then tends to accumulate in the blood.

GALVANIC GILDING.—M. Rod gives the composition of a bath to be used at temperatures from 50° to 80° C. It consists of 60 parts crystalline phosphate of soda, 10 parts bisulphate of soda, 1 part cyanide of sodium, 2½ parts chloride of gold, and 1,000 distilled water. In order to prepare the bath the water is divided into three portions of 700, 150, and 150 respectively. The phosphate of soda is dissolved in the first lot, the chloride of gold in the second, and the other ingredients in the third. The two first portions are gradually mixed together, and the third is then slowly added. A platinum plate is used as anode.—*Le Monde de la Science.*

RADIATION THROUGH EBONITE.—Captain Abney exhibited at the Physical Society of London, a number of photographic negatives taken by himself and Colonel Festin by radiation through thin sheets of ebonite. The light from the positive pole of an electric lamp was sent through a thin sheet of ebonite $\frac{1}{64}$in. thick, and photographs taken showed the radiation to have a low wave-length, from 8,000 to 14,000. The carbon points of the lamp could be photographed through the sheet, and Colonel Festin observed the sun's disc through it. The ebonite showed a grained structure, and different samples of ebonite gave different results, but all gave some result, in course of time at least; old ebonite, like that used in some of Mr. Preece's experiments, scattering the light more than new ebonite. Dr. Moser exhibited the passage of the rays through the ebonite to the audience by means of a galvanometer. Professor Guthrie observed that Captain Abney had proved that light as well as heat traversed the ebonite, and Dr. Coffin stated that compositions of ebonite, apparently the same, might vary considerably.

PHOTOGRAPHIC PHOTOMETRY.—A promising application of photography to precise measurement of phenomena of light has been recently tried by M. Janssen. The method is advantageous in that photography reveals the action of the extremely weak luminous and the ultra-violet rays; but the chief advantage lies in the permanence of the results as against the fugitive nature of ordinary photometric comparisons, which, too, require the simultaneous presence of the two light sources. The various amounts of metallic deposit on the photographic plate cannot well be weighed, so M. Janssen measures by the degree of opacity produced. His photometer consists of a frame with sensitised plate, before which is passed at a known rate of uniform motion a shutter having a slit. If this slit were rectangular, a uniform shade would be produced on the plate; but by making it triangular he obtains a variation of shade, decreasing from the side corresponding to the base of the triangle to that corresponding to the apex. It is further proved that the photographic deposit does not increase as rapidly as the luminous intensity. Now, to compare the sensibility of two plates differently prepared, they have merely to be exposed successively in the frame under like conditions, and the points where they show the same opacity being compared to the points of the triangular slit corresponding to them, the ratio of the apertures at those points expresses the ratio of sensibility. Thus the new gelatino-bromide of silver plates are proved to be twenty times as sensitive as the collodion plates prepared by the wet process. Again, to compare two luminous sources, they are made to act successively on two similar plates in the photometer, and the points of equal shade in the plates indicate, as before, the relation sought. M. Janssen has compared the light of the sun and some stars on these principles, preparing from the former "solar scales" (with uniform degradation of shade), under exactly determined conditions as to sensitive layer, time of solar action, height of the sun, etc. Circular images of stars are obtained by placing a photographic plate a little out of focus in the telescope, and a series of these, got with different times of exposure, are compared with the scales obtained from sunlight. M. Janssen will shortly make known some of his results.

SCIENCE

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